



Research Development and Technology

Missouri
Department
of Transportation

1617 Missouri Blvd.
P.O. Box 270
Jefferson City,
Missouri 65101



Comparison of Compressive Strengths Using 4x8 vs. 6x12 Cylinders for Prestress Concrete

Description:

Recently, prestress/precast companies are requesting to use smaller cylinder specimens, in particular 4 by 8-in. cylinders, for concrete compressive strength tests. The Missouri Department of Transportation (MoDOT) currently allows only the standard 6 by 12-in. cylinders in prestress fabrication. With smaller cylinders a person can handle them easier, spend less time and effort preparing them, and use less material. However, there is a debate over the strengths of the 4 by 8-in. cylinders compared to 6 by 12-in. cylinders. Typically, strengths of 4 by 8-in. cylinders are known to be higher than strengths of 6 by 12-in. cylinders for the same mix at the same age. Therefore, a laboratory research project was conducted to determine if there could be a comparison between 4 by 8-in. cylinders and 6 by 12-in. cylinders and then a correlation established.

Three mix designs were used representing MoDOT's Class A-1 concrete used in pre-stress production. Each mix composed of three batches to make 24 specimens, consisting of twelve 6 by 12-in. cylinders and twelve 4 by 8-in. cylinders. Fresh concrete characteristics are listed in Table 1.

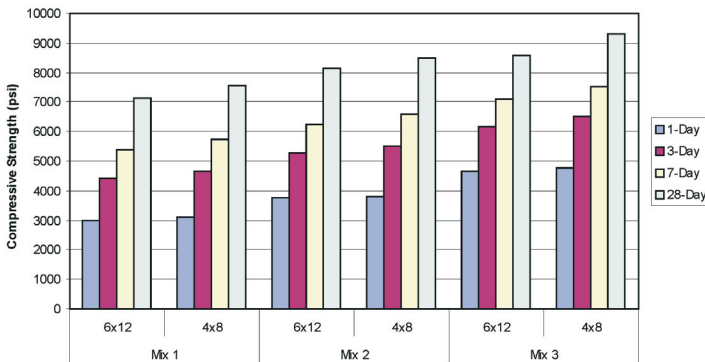
Table 1 - Fresh Concrete Characteristics

| Mix No. | Batch | w/c ratio | Slump (in) | Air (%) | Cementitious Content (sacks/yd ³) |
|----------------|-------|--------------|-------------|------------|--|
| 1 | A | 0.385 | 2.00 | 5.6 | 6.40 |
| | B | 0.385 | 3.50 | 7.8 | 6.40 |
| | C | 0.385 | 2.50 | 6.0 | 6.40 |
| Average | | 0.385 | 2.67 | 6.5 | 6.40 |
| 2 | A | 0.345 | 3.00 | 6.6 | 7.20 |
| | B | 0.345 | 2.25 | 5.7 | 7.20 |
| | C | 0.350 | 1.50 | 5.3 | 7.20 |
| Average | | 0.347 | 2.25 | 5.9 | 7.20 |
| 3 | A | 0.315 | 1.00 | 4.9 | 8.00 |
| | B | 0.315 | 2.00 | 4.6 | 8.00 |
| | C | 0.315 | 0.75 | 3.9 | 8.00 |
| Average | | 0.315 | 1.25 | 4.5 | 8.00 |

Laboratory Results and Findings:

Compressive strength data was collected from 1, 3, 7 and 28 days concrete test specimens from both the 4 by 8-in. cylinders and 6 by 12-in. cylinders. Three specimens per age per mix were tested. Figure 1 graphically illustrates the average compressive strengths of each mix design.

Figure 1 - Average Compressive Strength



The slump and air tests were conducted on all mixes according to AASHTO T119 and AASHTO T152, respectfully. The laboratory specimen fabrication and curing was performed in accordance with AASHTO T126. The compressive strength test for the 4 by 8-in. cylinders and the 6 by 12-in. cylinders was done according to ASTM C1231 and AASHTO T22, respectfully.

The percent differences between the 4 by 8-in. and the 6 by 12-in. cylinders were calculated for the three mixes and are listed in Table 2. The calculations assumed that the 4 by 8-in. cylinders would break higher than the 6 by 12-in. cylinders and are indicated by positive values.

Table 2 - Percent Difference

| Mix No. | Percent Difference | | | |
|---------|--------------------|-------|-------|--------|
| | 1-Day | 3-Day | 7-Day | 28-Day |
| 1 | +4% | +5% | +6% | +6% |
| 2 | +1% | +4% | +5% | +4% |
| 3 | +2% | +5% | +6% | +8% |
| Avg. | +2% | +5% | +6% | +6% |

Consistently, the 4 by 8-in. cylinders broke higher than the 6 by 12-in. cylinders. In only two individual cases the 4 by

8-in. cylinder broke lower (less than 30 psi) than the 6 by 12-in. cylinder. The maximum percent difference between an individual 4 by 8-in. cylinder and an individual 6 by 12-in. cylinder was +10%. Generally, the difference in compressive strengths between the 4 by 8-in. cylinders and the 6 by 12-in. cylinders increased over time.

Based on the compressive strength differences observed in this study, a multiplier of 0.94 applied to the results of the 4 by 8-in. cylinders should provide reliable compressive strength acceptance data, which can be used in lieu of 6 by 12-in. cylinder strength data. This would enable the use of 4 by 8-in. cylinders on a routine basis resulting in easier handling and saving in time, effort and material.

Recommendations:

Based on the laboratory results from this study, the following recommendations were made:

- Allow the use of 4 by 8-in. cylinders with a correction factor of 0.94 when determining compressive strength acceptance of MoDOT Class A-1, prestress, concrete at the plant with a semi-controlled environment.
- When fabricating the 4 by 8-in. cylinders, AASHTO T 23 requirements shall be followed, which specifies a “small rod” and two equal depth layers, rodged 25 times per layer.
- The retainer used with neoprene pads when testing for compressive strength of the 4 by 8-in. cylinders should be constructed according to ASTM C 1231.

Implementation:

MoDOT’s Construction and Materials Functional Unit has recently revised Field Section 705, Prestressed Concrete Members for Bridges, in the Materials Manual to incorporate the results of this study. When finalized, this section will be found in the Materials Manual, Field Section 705.3.8.1, Concrete Testing.

Contact Information:

Patrick J. Hake, E.I.T.
Research and Development Assistant
Phone: (573) 526-4332
E-mail: Patrick.Hake@modot.mo.gov



Missouri Department of Transportation
Research, Development and Technology
1617 Missouri Blvd.
P.O. Box 270
Jefferson City, MO 65102

Phone: (573) 751-3002
1-888-ASK MODOT
Email: rdtcomments@modot.mo.gov
Web Address: www.modot.org/services/rdt